

Being an Synthetic Organic Chemist, I spent the past weeks synthesizing several compounds and here's the results:

A. Determine the Empirical Formulae:

1.	H	2.055%	$2.055 \text{ g} / 1.008 \text{ g/M} = 2.039 \text{ M}$	$2.039 \text{ M} / 1.020 \text{ M} = 1.999$	= 2
	S	32.70%	$32.70 \text{ g} / 32.07 \text{ g/M} = 1.020 \text{ M}$	$1.020 \text{ M} / 1.020 \text{ M} = 1$	= 1
	O	65.25%	$65.25 \text{ g} / 16.00 \text{ g/M} = 4.078 \text{ M}$	$4.078 \text{ M} / 1.020 \text{ M} = 3.998$	= 4



2.	C	59.96%	$59.96 \text{ g} / 12.01 \text{ g/M} = 4.993 \text{ M}$	$4.993 \text{ M} / 1.664 \text{ M} = 3.001$	= 3
	H	13.42%	$13.42 \text{ g} / 1.008 \text{ g/M} = 13.31 \text{ M}$	$13.31 \text{ M} / 1.664 \text{ M} = 7.999$	= 8
	O	26.62%	$26.62 \text{ g} / 16.00 \text{ g/M} = 1.664 \text{ M}$	$1.664 \text{ M} / 1.664 \text{ M} = 1$	= 1



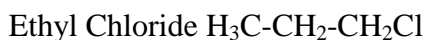
3. A 3.450 g of a sample of nitrogen reacts with 1.970 g of Oxygen.

3.450 g N	$3.450 \text{ g} / 14.01 \text{ g/M} = 0.2463 \text{ M}$	$0.2463 \text{ M} / 0.1231 \text{ M} = 2.001$
1.970 g O	$1.970 \text{ g} / 16.00 \text{ g/M} = 0.1231 \text{ M}$	$0.1231 \text{ M} / 0.1231 \text{ M} = 1$



4. An organic chemical gives the following analysis:

5.667 g Carbon	$5.667 \text{ g} / 12.01 \text{ g/M} = 0.4719 \text{ M}$	$0.4719 \text{ M} / 0.1570 \text{ M} = 3.006$
0.3165 g Hydrogen	$0.3165 \text{ g} / 1.008 \text{ g/M} = 0.3140 \text{ M}$	$0.3140 \text{ M} / 0.1570 \text{ M} = 2$
5.566 g Chlorine	$5.566 \text{ g} / 35.45 \text{ g/M} = 0.1570 \text{ M}$	$0.1570 \text{ M} / 0.1570 \text{ M} = 1$



5.	Cu	66.75%	$66.75 \text{ g} / 63.55 \text{ g/M} = 1.050 \text{ M}$	$1.050 \text{ M} / 0.3500 \text{ M} = 3$
	P	10.84%	$10.84 \text{ g} / 30.97 \text{ g/M} = 0.3500 \text{ M}$	$0.3500 \text{ M} / 0.3500 \text{ M} = 1$
	O	22.41%	$22.41 \text{ g} / 16.00 \text{ g/M} = 1.401 \text{ M}$	$1.401 \text{ M} / 0.3500 \text{ M} = 4.003$



6. A compound containing only Carbon, Hydrogen and Oxygen gives the following analysis:

C	40.00%	40.00 g / 12.01 g/M = 3.331 M	3.331 M / 3.331 M = 1
H	6.700%	6.700 g / 1.008 g/M = 6.647 M	6.647 M / 3.331 M = 1.995
O	100 % - 40.00% - 6.700% = 59.33 % O	53.30 g / 16.00 g/M = 3.331 M	3.331 M / 3.331 M = 1

C₁H₂O

$$C_1H_2O_1 = 12.01 + 2 * 1.008 + 16.00 = 30.03 \text{ g / M}$$

The Molar Mass is between 115 and 125 g/mole. What is the Empirical and Molecular formulae.

$$2 * 30.03 = 30.06 \quad 3 * 30.03 = 90.09 \quad \underline{4 * 30.03 = 120.12} \quad 4 * C_1H_2O_1 = C_4H_8O_4$$

7. An organic compound containing only C, H, N and O has the following analysis

C	49.47%	49.47 g / 12.01 g/M = 4.119 M	4.119 M / 1.03 M = 3.999
H	5.191%	5.191 g / 1.008 g/M = 5.149 M	5.149 M / 1.03 M = 4.999
N	28.86%	28.86 g / 14.01 g/M = 2.060 M	2.060 M / 1.03 M = 2
O	100% - 49.47% - 5.191% - 28.86% = 16.48% O	16.48 g / 16.00 g/M = 1.03 M	1.03 M / 1.03 M = 1

C₄H₅N₂O

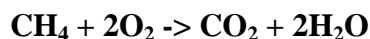
$$C_4H_5N_2O = 4 * 12.01 + 5 * 1.008 + 2 * 14.01 + 16.00 = 90.09$$

The approximate molar mass is 194. What is the Empirical and Molecular formulae.

$$2 * 90.09 = 192.18 \quad \underline{2 C_4H_5N_2O = C_8H_{10}N_4O}$$

B. Determine the following [Show all math with canceled units and balanced equations]:

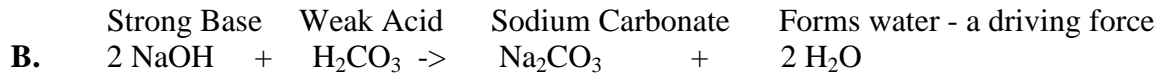
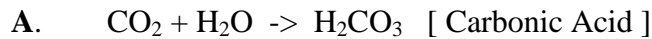
1. From the hood experiment, we learned that natural gas, Methane, will burn form carbon dioxide and wate formed from burning 50 g of Methane?



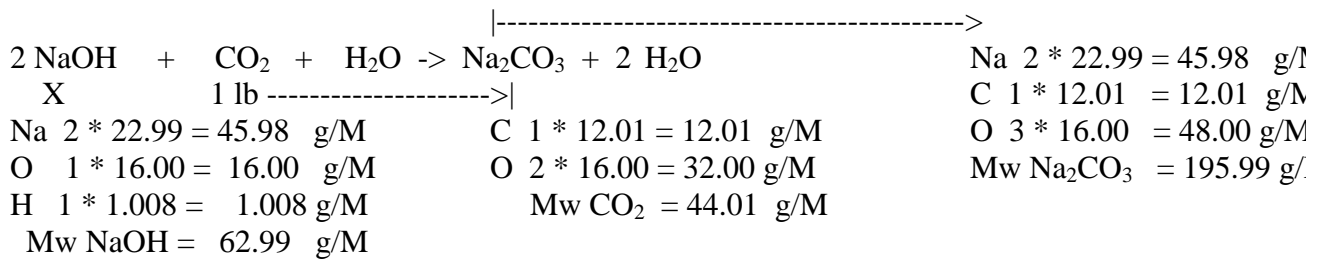
50 g	----->	
1 C = 1 * 12.01 = 12.01 g/M		4 H = 4 * 1.008 = 4.032 g/M
4 H = 4 * 1.008 = 4.032 g/M		2 O = 2 * 16.00 = 32.00 g/M
Mw CH ₄ = 16.04 g/M		Mw 2H ₂ O = 36.032 = 36.03 g/M

$$\frac{50 \text{ g Methane}}{16.04 \text{ g/M}} = \frac{X}{36.03 \text{ g/M}} = 112.312 \text{ g H}_2\text{O} = \underline{110 \text{ g H}_2\text{O}} \text{ [2 sign digits]}$$

2. Sodium Hydroxide is used in rebreathers units to absorb carbon dioxide. The reaction of sodium hydroxide produces sodium carbonate and water. As we all know, since water is produced, the reaction will go to completion. How much of sodium hydroxide is needed to react with 1 pound of carbon dioxide? How much Sodium Carbonate is formed?



Replace the H_2CO_3 in B with the Carbonic Acid in A above:



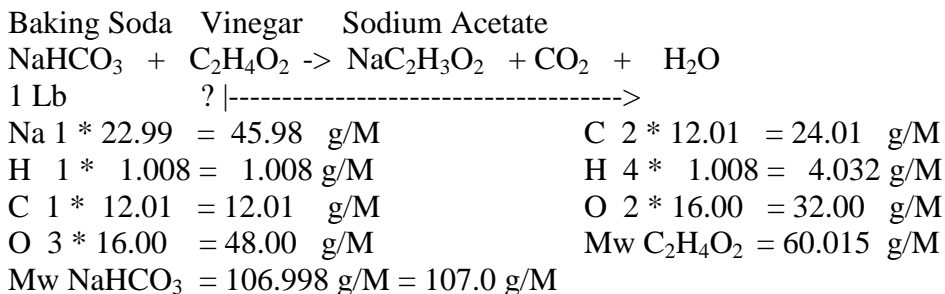
1 lb = 453.6 g of carbon dioxide

$$\frac{453.4 \text{ g CO}_2}{44.01 \text{ g/M}} = \frac{X}{62.99 \text{ g/M}} \quad \mathbf{X = 648.9 \text{ g NaOH} = 600 \text{ g NaOH [1 sign digit]}$$

$$\frac{453.4 \text{ g CO}_2}{44.01 \text{ g/M}} = \frac{X}{195.99 \text{ g/M}} \quad \mathbf{X = 2019.12 \text{ g Na}_2\text{CO}_3 = 2000 \text{ g [1 sign digit]}$$

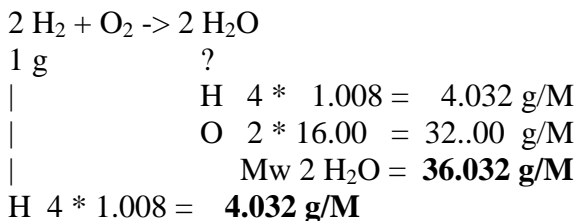
3. Baking Soda will is slightly basic and will react with vinegar to form sodium acetate, water and carbon di complete balanced reaction. How many grams of vinegar is needed to react with a one pound box of baking

Baking Soda = Sodium Bicarbonate = NaHCO_3 Vinegar = acetic acid = $\text{H}_3\text{C-COOH} = \text{C}_2\text{H}_4\text{O}_2$
 Sodium Acetate = $\text{H}_3\text{C-COO}^- \text{Na}^+ = \text{NaC}_2\text{H}_3\text{O}_2$

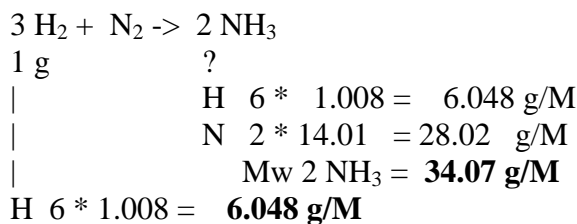


$$\frac{453.6 \text{ g NaHCO}_3}{107.0 \text{ g/M}} = \frac{x}{60.015 \text{ g/M}} \quad \mathbf{X = 254.56 \text{ g Vinegar} = 300\text{g [1 Sign Figure]}$$

4. 1.00 g of Hydrogen reacts with Oxygen to form water. 1.00 g of Hydrogen also can react with Nitrogen to form ammonia. Calculate the amounts of water and ammonia formed in each reaction?

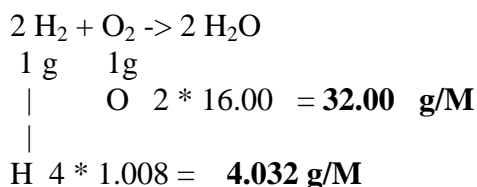


$$\frac{1 \text{ g}}{4.032 \text{ g/M}} = \frac{X}{36.032 \text{ g/M}} \quad \mathbf{X = 8.94 \text{ g Water [3 Sign Digits]}$$



$$\frac{1 \text{ g}}{6.048 \text{ g/M}} = \frac{X}{34.07 \text{ g/M}} \quad \mathbf{X = 5.63 \text{ G Ammonia [3 Sign Digits]}}$$

5. From the above equations, 1.00 g of Hydrogen is reacted with 1.00 g of Oxygen. What reactant is in excess?

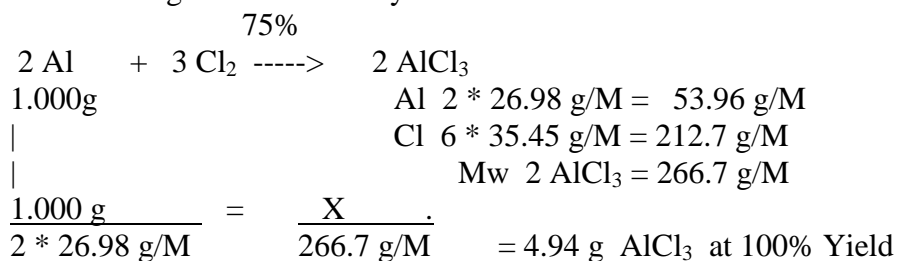


$$\text{H} = \frac{1 \text{ g}}{4.032 \text{ g/M}} = \mathbf{0.248 \text{ M [3 Sign Digits]}} \qquad \text{O} = \frac{1 \text{ g}}{32.00 \text{ g/M}} = \mathbf{0.0313 \text{ M [3 Sign Digits]}}$$

There is more Molar Ratios of Hydrogen than Oxygen, so Hydrogen is in excess.

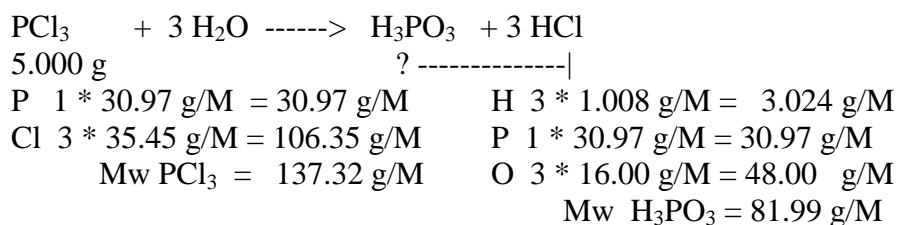
$$0.248 \text{ M H} - 0.0313 \text{ M O} = \mathbf{0.217 \text{ M H in xcs.}}$$

6. Aluminum reacts with Chlorine to form Aluminum Chloride. How much Aluminum Chloride is produced from 1.000 g of Aluminum assuming a 75% reaction yield?



$$4.94 \text{ g AlCl}_3 \text{ at 75\% Yield} = 4.94 \text{ g} * 0.75 = \mathbf{3.707 \text{ g AlCl}_3 [4 Sign Digits]}$$

7. Phosphorous Tri Chloride will react with water to produce Phosphorous Acid. What is the Theoretical Yield of Phosphorous Tri Chloride?



$$\frac{5.000 \text{g}}{137.32 \text{ g/M}} = \frac{X}{81.99 \text{ g/M}} \qquad \qquad \mathbf{X = 2.985 \text{ g H}_3\text{PO}_3 \text{ at 100\% Yield}} \\
 \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \mathbf{[4 \text{ sign digits }]}$$